GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Kalman Filters and Stochastic Control, PG_00064537		
Field of study	Automatic Control, Cybernetics and Robotics		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2024/2025
Education level	second-cycle studies	Subject group	Optional subject group Specialty subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	English
Semester of study	2	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Automatic Control -> Faculty of Electronics Telecommunications and Informatics -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Artur Gańcza	
	Teachers	dr inż. Artur Gańcza	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	15.0	0.0	30

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	30	4.0	16.0	50

Subject objectives

Introducing design methods for regulation systems working in random conditions.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W01] knows and understands, to an increased extent, mathematics to the extent necessary to formulate and solve complex issues related to the field of study	Students know basic kinds of random processes and Markov's decision problems.	[SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation
[K7_W02] knows and understands, to an increased extent, selected laws of physics and physical phenomena, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences related to the field of study	Students understand basic properties of random processes, know basic estimation and control techniques of random processes and understand their operating principles.	[SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation

<table>
<tr><td>Subject contents</td><td>1. Principles of minimum variance (MV) control
2. MV regulators for ARMAX systems
3. Stability of MV regulators
4. Diophantine equations and their solutions
5. MV tracking of a reference signal
6. Limitations and drawbacks of MV control
7. Moving average (MA) control
8. Linear quadratic (LQ) control principles
9. Design of LQ regulators
10. Principles of minimum variance estimation
11. Introduction to Kalman filtering conditional densities of Gaussian variables
12. Prediction, filtration and smoothing of stochastic signals
13. Kalman predictor and Kalman filter
14. Properties of Kalman filter
15. Stationary Kalman filter Wiener filter
16. Kalman filter as an optimal state observer
17. Application of Kalman filter to airplain tracking
18. Numerical safeguards used in Kalman filtering
19. Extended Kalman filter (EKF)
20. Application of EKF to localization of an automous guided vehicle
21. LQ regulators in state space
22. Separation theorem
23. Robustness of LQ regulators
24. Markov Chains
25. Estimation methods based on Bayesian approach to combining multiple models</td></tr>
<tr><td>Prerequisites and co-requisites</td><td></td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Midterm colloquium</td><td>52.0%</td><td>100.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>Anderson, B. D., & Moore, J. B. (2005). Optimal filtering. Courier Corporation. New York, 2005.</td></tr>
<tr><td>Supplementary literature</td><td>Bar-Shalom, Y., Li, X. R., & Kirubarajan, T. (2001). Estimation with applications to tracking and navigation: theory algorithms and software. John Wiley & Sons. New York, 2001.</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>1. What assumptions are required for the Kalman filter to be the minimum-variance estimator? Describe how the Kalman filter works.
2. What is the LQG controller, and how does it differ from the LQR controller? Describe properties of an LQG controller.
3. Explain the invertibility of the moving average process, and why is it important? Explain differences in autocorrelation function and spectral density function of an invertible and uninvertible representations of the moving average process.
4. What is a moving average controller? What are its properties? How does it differ from the minimumvariance
controller?
5. What is the autonomous multiple models (AMM) method? What are its assumptions? How does it differ from the interacting multiple models (IMM) method?</td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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